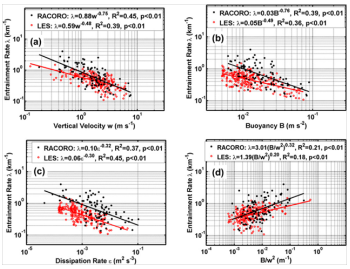
Improving Entrainment Rate Parameterization

Research Highlight

Parameterization of entrainment rate is critical for improving representation of cloud- and convection-related processes in climate models; however, much remains unclear.

This work seeks to improve understanding and parameterization of entrainment rate by use of aircraft observations and large-eddy simulations of shallow cumulus clouds over the U.S. Department of Energy's Atmospheric Radiation Measurement Climate Research Facility's Southern Great Plains site, collected during the Routine AAF CLOWD Optical Radiative Observations (RACORO) field campaign.

It is found that entrainment rate, in both observed and simulated clouds, exhibits similar negative correlations with updraft velocity, buoyancy, and turbulent dissipation rate. Based on these relationships, a hierarchy of new parameterizations is developed to consider all these variables one by one with the stepwise principal-component regression. Also explored are the physical mechanisms underlying the relationships between entrainment rate, vertical velocity, buoyancy, and turbulent dissipation rate.



Relationships are showen here between entrainment rate and (a) vertical velocity w, (b) buoyancy B, (c) dissipation rate e, and (d) B/w2 in 102 actively growing cumulus clouds during RACORO. Also shown for comparison are the results from large-eddy simulations. The parameter R2 is the adjusted coefficient of determination, and p shows the significance level.

Reference(s)

Lu C, Y Liu, GJ Zhang, X Wu, S Endo, L Cao, Y Li, and X Guo. 2016. "Improving parameterization of entrainment rate for shallow convection with aircraft measurements and large-eddy simulations." Journal of the Atmospheric Sciences, 73(2), doi:10.1175/JAS-D-15-0050.1.

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Cloud Life Cycle